MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2019/2020

DCE5028 – ELECTRICAL MACHINES AND POWER SYSTEMS

(Diploma in Electronics Engineering)

18 OCTOBER 2019
3.00 p.m. – 5.00 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of 5 pages (excluding the cover page).
2. Answer **ALL** questions. All necessary working steps must be shown.
3. Write all your answers in the answer booklet provided.

Question 1

(a) A ferromagnetic core with relative permeability of 1000 is shown in Figure Q1(a). The depth of the core is 5 cm. A coil of 500 turns is wound on the core limb having cross-sectional area of 50 cm^2. The length of air-gap is 0.07 cm. Due to fringing effect, the effective area of the air gap increases by 6%. The flux density in the air-gap is 0.66 Tesla.

(i) Draw the equivalent circuit for the magnetic circuit [2 marks]

(ii) Find the flux in the air gap. [2 marks]

(iii) Determine the current required in the coil [9 marks]

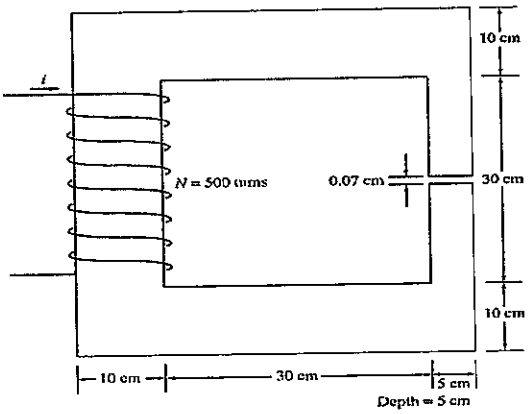


Figure Q1(a)

(b) A three phase Y-connected load with an impedance per phase of 25 Ω with 0.8 power factor lag, is supplied from a delta-connected three phase supply with a line voltage of 400 V.

(i) Draw the equivalent circuit of the system. [2 marks]

(ii) Determine the magnitudes of the line and phase voltages of the load. [2 marks]

(iii) Determine the magnitudes of the line and phase currents of the load and supply. [4 marks]

(iv) Find the total real power and reactive power consumed by the load [4 marks]

Continued...

Question 2

(a) A 1200/400 V transformer has a resistance of 5 Ω and a reactance of 9 Ω in the primary side. The secondary side resistance is 0.6 Ω and reactance is 1.1 Ω. The secondary is supplying a current of 5 A at a power factor of 0.8 lag. The secondary load voltage is 400V.

(i) Draw the equivalent circuit referred to the secondary and label the parameters. [4 marks]

(ii) Determine the equivalent resistance and reactance referred to secondary. [4 marks]

(iii) Find the voltage regulation. [5 marks]

(b) A DC shunt generator has an armature resistance of 0.25 Ω and a field resistance of 60 Ω. The generator delivers 6 kW at a terminal voltage of 120 V. The stray losses in the generator are 1500 W.

(i) Draw the equivalent circuit of the generator and mark the parameters. [3 marks]

(ii) Determine the generated EMF. [4 marks]

(iii) Calculate the mechanical power input and efficiency of the generator. [5 marks]

Continued...

Question 3

(a) A 400 V, 3-phase,4 pole,50Hz Y-connected induction motor produces an output power of 20 kW at a speed of 1410 rpm. The mechanical losses are 2 kW. The stator losses are 1.5 kW. The rotor copper loss is 1.2 kW. The input power factor is 0.8 lag. Determine

(i) the synchronous speed and slip, [3 marks]

(ii) the input power, [3 marks]

(iii) the input line current, [3 marks]

(iv) the efficiency and [2 marks]

(v) the shaft torque. [2 marks]

(b) A 3-phase,4 pole, 12kW, 400V,50Hz, star connected synchronous generator has a synchronous reactance of 2 Ω/phase. The resistance can be assumed as negligible. It supplies rated power at rated voltage to a load at a power factor of 0.8 lag.

(i) Draw the single phase equivalent circuit and indicate all parameters. [2 marks]

(ii) Determine the generated emf per phase. [8 marks]

(iii) Determine the voltage regulation. [2 marks]

Continued....

Question 4

(a) Calculate the per unit(p.u.) impedances of the following:
   (i) Generator:30 MVA,11 kV, X= 20% to a base of 60 MVA,22 kV. [3 marks]
   (ii) Transmission line: X=j80 Ω to a base of 400 kV and 100 MVA. [3 marks]

(b) Name any two renewable energy sources which have potential to replace conventional power plants and state their advantages. [4 marks]

(c) Explain the function of a circuit breaker and its advantages over fuse. [4 marks]

(d) Name three types of circuit breakers and explain how arc is extinguished in these. [6 marks]

(e) An IDMT relay is connected to a 400/5 A current transformer. Calculate the relay coil current and the value of P.S.M. for a fault current of 1200 A and a current setting of 150%. [5 marks]

End of Page

Appendix

Magnetic Circuit

$\mathbf{F} = Ni = \Re_{eq}.\Phi = Hl$ $\quad \Re_c = \dfrac{l_c}{\mu_c A_c}$ $\quad B = \dfrac{\Phi}{A_c}$

$\mu_c = \mu_r \mu_0$ $\quad \mu_0 = 4\pi \times 10^{-7}$ H/m

$E = \dfrac{\Phi ZN}{60} \times \dfrac{P}{A}$ $\quad \tau = \dfrac{1}{2\pi}\left(\dfrac{P\Phi Z}{A}\right) I_a$ $\quad P_M = \tau . \omega = EI_A = P_E$

DC Machines

$V_t = E - R_a I_a$ (Shunt Generator) $\quad \eta = \dfrac{P_{out}}{P_{in}} \times 100$

$V_t = E + R_a I_a$ (Shunt Motor)

Armature copper loss = $I_a^2 R_a$ $\quad$ Field copper loss = $I_f^2 R_f$

Transformer

$a = \dfrac{E_1}{E_2}$ $\quad V_2 = E_2 - I_2(R_{e2} + jX_{e2})$ $\quad R_{e1} = R_1 + a^2 R_2$ $\quad R_{e2} = \dfrac{R_1}{a^2} + R_2$

Voltage regulation = $\dfrac{E_2 - V_2}{V_2} \times 100$ $\quad X_{e1} = X_1 + a^2 X_2$ $\quad X_{e2} = \dfrac{X_1}{a^2} + X_2$

Three-phase Circuits

Δ: $\quad V_L = V_\phi$ $\quad I_L = \sqrt{3} I_\phi$

Y: $\quad V_L = \sqrt{3} V_\phi$ $\quad I_L = I_\phi$

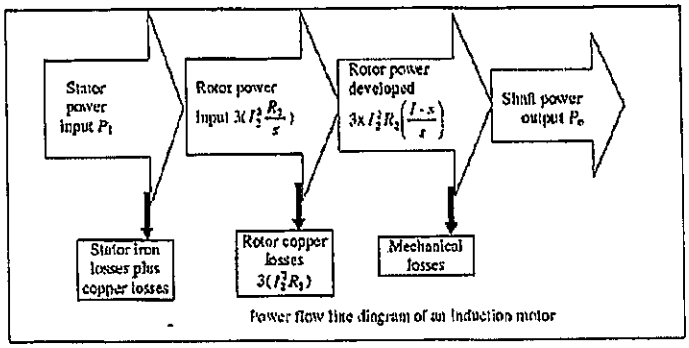
$S = 3V_\phi I_\phi = \sqrt{3} V_L I_L$

$P = 3V_\phi I_\phi \cos\theta = \sqrt{3} V_L I_L \cos\theta$

$Q = 3V_\phi I_\phi \sin\theta = \sqrt{3} V_L I_L \sin\theta$

Induction Motor

$n_s = \dfrac{120f}{p}$ $\quad s = \dfrac{n_s - n}{n_s}$


Stator power input P_i
Rotor power input $3(I_2^2 \frac{R_2}{s})$
Rotor power developed $3xI_2^2 R_2\left(\frac{1-s}{s}\right)$
Shaft power output P_o
Stator iron losses plus copper losses
Rotor copper losses $3(I_2^2 R_2)$
Mechanical losses
Power flow line diagram of an induction motor

Synchronous Machines

$X_S = \dfrac{E_{open-circuit}}{I_{short-circuit}}$

$P = \dfrac{E_c V}{X_s} \sin\delta$

$E_c = V - I_a(Ra + jX_s)$

Per-unit Value

$$per-unitZ_{new} = per-unitZ_{given}\left(\frac{basekV_{given}}{basekV_{new}}\right)^2\left(\frac{basekVA_{new}}{basekVA_{given}}\right)$$